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COMPUTATION OF RELATIVE INDEX RANKING OF VARIOUS CONSTRUCTION PRODUCTIVITY FACTORS

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ABSTRACT

India is one of the biggest developing country in world. The construction industries is the major sector in India which governed the economic growth of country, However low productivity has been a major problem faced by this sector. Construction projects suffer various problems and complex factors such as cost, duration, quality and safety. This study is focused on improving the productivity in construction sector. For finding out the most important factors affecting construction productivity detailed survey is carried out with the help of questionnaire. Questionnaire survey is carried out by selecting major construction company in Pune region through direct and indirect employees. The analysis of the database collected is used for finding the most effective factors which influences the productivity in the construction.

Questionnaire is formulated on the basis of previous studies. And analysis of the survey questionnaire is useful to define and develop the factors governing productivity. The present study shows that factors such as salary expectation, promotion and motivational practices are found to be main reason affecting productivity. Finally further analysis seems to show that some factors affecting productivity are common to every project. The relative index has been found out to rank the factors according to the importance in productivity. Detailed case study is carried out for validating the most important and effective factors which influence the productivity of the construction.

KEYWORDS: Productivity in Construction, Productivity Improvement, Construction Factors, Relative Index

INTRODUCTION

The construction industry in India plays a major role in economic development of the country. The construction industry has strong competition in India itself and also with foreign companies for the major projects. KP developer is the one of the known companies in Pune and Bangalore. KPDL's extensive spectrum of creations spans across multiple segments like residential projects, business and retail properties, IT Parks, Integrated Townships and Hospitality Infrastructure. For such huge construction they have challenges such as prices, financial management, safety management, increased completion, skilled labor such issues are very carefully assessed while awarding jobs to contractor. In this scenario, construction productivity plays a vital role in determining the financial management and duration of the project.

There is no standard way to define productivity for construction operations. Productivity is defined as output divided by input. The first step of this case study is find the factors of construction productivity which has been already found out in the previous research studies. After collecting and gathering data from various previous research studies in construction productivity, the questionnaire of twenty four construction productivity factors has been prepared and analyzed for the further studies. This questionnaire has been distributed to various KPDL ongoingprojects for the collection of data. Calculations and effects of selected factors are required for several purposes, such as planning and scheduling.

SCOPE OF THE STUDY

However, previous study shows that it is not an easy task to calculate the impact of various factors on loss of productivity. At present there no such universally accepted standards to measure factors causing construction productivity loss in construction industry. When we are referring to the productivity it means the overall productivity on the site, this includes every department that is involved from its inception to its completion in the construction activity. Also in other traditional means productivity is different in various fields such as labor productivity in factory, fuel productivity in electric power stations, and land productivity in farming.

For measuring effects of factors influencing productivity highlights the need to enhance measureable assessments in building construction. Thisstudy will help in improving the productivity of the construction on site. In this study various, direct and indirect, execution and management employees from different department of the construction site are surveyed and analyzed to obtain optimum results of the constructionproductivity.

LITERATURE REVIEW

Productivity is very important in any type of construction and has greater importance in recent times. There is variety of literature available on construction productivity. But less literature available and performed in India. So it is necessary to find out and improve the construction productivity factors. Several authors have performed wide variety work on finding productivity factors they are:

Edwards et al. 2007; Love et al. 2005

In Australia, research work of factors affecting productivity such as rework and worker's performance and motivation was studied by Edwards and Love. Author studied the various methods to find and improve productivity factors which affectsthe overall construction productivity.Further research work done by, Faridi and El-Sayegh (2006) reported that shortage of manpowerskills, poor supervision and unsuitable leadership, poor site management, breakdown and shortage of equipment among others contribute to construction delays in the United Arab Emirates.

George Jorge's P, Die et al (2009)

In Canada, Productivity Alberta (2009) demonstrated to determine the needs of productivity improvement and identifying the factors affecting construction productivity on delivery of oil and gas capital projects.Author surveyed very experienced personnel from owner organizations and presented categorized industrial recommendations tabulated into 10 major areas. They found out that the factors affecting the construction productivity are capital, labor, material, time etc. Technical problems like lack of information or complete drawing, design and specification lead to delay and increase in cost of project. The above factors have been categorized and attempt has been made to find the productivity level of the organization and how and where the construction productivity factors are lacking so that the productivity can be increased. (Statistics Canada and Alberta Enterprise & Advanced Education) (Productivity Alberta, 2008).

Liberda et al. (2003)

Carried out research work in University of Calgary and identified the relative importance of fifty one productivity factors which were classified into three groups: Human, External, and Management. The following are some the productivity factors identified:

- Human factors such as worker motivation, worker boredom and fatigue, worker attitude and morale, worker's physical limitations

- External factors such as union rules and influences, adverse weather conditions, noise, dust, radiation, congested work area
- Management factors such as protective gear, unrealistic schedules, overtime, multiple shifts, excessive shift length, disrespectful treatment of workers, parking facilities, salary and benefits, site layout

William F. Maloney (1981)

The authors focused attention on worker compensation and productivity issue are neglected in the United States' construction industry. However, their work is to address many important questions related to the financial incentive programs (FIP) in construction. The author used Delphi technique to ascertain the opinions of the feasibility of the use of financial incentives program to increase construction productivity. However, the validity in this application is diminished because the primary groups to be covered by the FIP reviewed in the work, craft-workers, were excluded from the panel. These workers will determine the effectiveness of FIP and, therefore, should have been represented on the panel.

Adnan Enshassi1, Sherif Mohamed. (2009)

Author surveyed construction projects located in the Gaza Strip, Palestine suffer from many problems and complex issues, the objective of this paper is to identify the factors affecting the performance of local construction projects and to perceptions of their relative importance. A comprehensive literature review was deployed to generate a set of factors believed to affect project performance. A total of 120 questionnaires were distributed to 3 key groups of project participants namely owners, consultants and contractors.

DETAILS OF THE CASE STUDY

The company analyzed is the well-known reputed company and its project is located all over in Pune. Kolte - Patil Developers has 28 ongoing projects in Pune, Bangalore. This company has 28 ongoing projects in Pune and Bangalore; 23 are residential and 5 are commercial. KPDL's extensive spectrum of creations spans across multiple segments like residential projects, business and retail properties, IT Parks, Integrated Townships and Hospitality Infrastructure. Its core business operations feature varied aspects of construction business, such as location identification, acquisition, project planning, designing and development. The company employs 150 fulltime people on contracts, and 1000 to 1400 people on contracted basis. The company works typically on 5 to 6 project simultaneously, in some case it also work in consortium or joint ventures with other construction company to acquire the objectives of the project.The company working under the ISO 9001 and also in safety it has maintained good performance. Out of number of ongoing project only three existing project are selected for this case study.

METHODOLOGY

An experimental work is conducted to obtain the relative index ranking of main factors influencing construction productivity. Various ongoing construction projects are analyzed and root cause of loss in construction productivity is found out by analyzing various construction productivity factors.A good understanding of factor affecting construction productivity will come out from various site engineer, supervisors, project manager, contractors and owners.

The fallowing stages were identified to achieve the goal of this study:

- A literature review was carried out on the factors affecting productivity.
- With the above literature review the people from various companies and the organizations site engineer, supervisors, project manager, contractors and owners are selected for the and constituted in this case study.

- A questionnaire was prepared on the basis of literature review and the experience of the site engineer, supervisors, project manager, contractors and owners.
- These questionnaires were circulated to various site personal, managers, contractors, consultants, owners.
- The information collected through various site surveys conducted and the information collected through the surveys is analyzed to find the main construction productivity influencing factors.
- The relative index ranking of main factors influencing the construction productivity is found out.
- The case study findings are then compared with the result of previous studies.
- The ranking of productivity main and sub factorsare arranged in descending order according to their effect on construction productivity, as shown in table 1.

Table 1: Main and Sub Factors Affecting Construction Productivity

Main Factors	Sub-Factors
Human Resource department	(1) Worker experience (2) Payment issues (3) Worker motivation (4) Absenteeism(5) Recruitment, training, selection
Execution department	(6) Change orders during Execution (7) Supervision factors (8) Working time factors(9)Leadership and coordination factors
Organization factors	(10) Rules and regulations (11) Size of an Organization (12)Type of organization
Construction methods	(13) Greater use of prefabrication (14) Greater use of automated equipment(15)Frequent damage of equipment's (16)Precast material
Technical factors	(17) Design of structure (18) Use of advance technique (19) Availability of drawing details (20)Non-availability of information and tools
External factors	(21) Inclement weather effects (22) Changes in government rules, regulation and laws (23) Audits (24) Noise, dust, radiation.

Source: From previous research studies and industrial site survey from industrial employees

Preparation of Survey Questionnaire

The data for this study is the result of questionnaire circulated to the various site personal and administrative and management people different department working on different projects. A procedure has been adopted to find the factors from each and every field and department which is directly related to the site such as design, human resource department, executiondepartment planning and management department so that the integrated approach for increasing construction productivity factors are obtained and the valid construction productivity factors are found to achieve the goal. Before circulating the questionnaire, a demonstration and the use of this questionnaire has been briefly explained to each and every person. Out of seventy selected factors only those factors will be selected which is mostly selected by the various personal (according to rank provided). The questionnaire prepared as shown in table 2 were discussed and explained with every person. This prepared questionnaire is used for finding out productivity influencing factors.

Table 2: Data Collected According to the Type of Work

Post of Qualification	Work Activity	Number	Total Number
(MIDDLE LEVEL) Senior design engineer			9
	Design	2	
Senior execution engineer	development	4	

Table 2: Contd.,

Senior safety officer	And execution	1	
Project engineer		2	
(JUNIOR LEVEL) Junior engineer	Execution and Supervision staff	7	19
Assistant J engineer		5	
Supervisor		6	
Total			**28**

Table 3: Questionnaire Characteristics: Project Information

Topics	Number of Question	People Interviewed
General	8	Mid
Personal data	6	and Junior
Design and engineering	5	Management
Material	6	Level
Rework	3	Employees
Tools and equipment	4	
Motivation	6	
Employee experience	7	
Drawing related	4	
Safety	3	
Labor related	8	
Site related	4	
Others	6	
Total	**70**	

RESULTS AND DISCUSSIONS

The questionnaire has been circulated to the various people and the analysis has done to find the most important productivity influencing factors according to the ranking provided by each personal to the factors in the questionnaire. The question put in questionnaire depend on various topics and number of question asked to the top and medium level management is described in the table 3. After collection of the questionnaire from various sites personal the above data is analyzed and on the basis of experience and qualification of the employee 10 most important factors influencing productivity is found out.The following tables 4, 5 and 6 showsthat how to find out the ranking of factors influencing construction productivity.

Table 4: Details of the Selected Project

PROJECT	1	2	3
Name	Ivy estate	Tuscan estate	Downtown
Owner	KPDL	KPDL	KPDL
Contractor	Local	Own	Local
Location	Wagholi	Kharadi	New kharadi
Duration (months)	30	24	36
Status	On schedule	Completed (Possession)	On schedule
Main works	Tower construction	Residential, shops	Township
Contract type	Item rate, unit price	Lump-sum type	Lump-sum type
No of accidents	2 with-out loss time	0 with loss type	0 with loss type
Work system	M-S; 6dw × 1dnw	M-S; 6dw × 1dnw	M-S; 6dw × 1dnw
People (D/I)	19(12/7)	12(8/4)	34(26/10)
Key: D = Direct; I = Indirect; M-S = Monday to Saturday: dw = days working; dnw = days non-working; ML = Mid-level; JL = Junior level			

Table 5: Main Factors Influencing Productivity

Total People Surveyed=28 (ML-9; JL-19)	Total Affirmative Responses			Percentage (%) (Affirmative Responses/Total People Surveyed) × 100		
Influence	**Total**	**Mid-Level**	**Junior Level**	**Total**	**Middle Level**	**Junior Level**
Materials	21	8	13	75	89	68
Design and engineering	16	6	10	57	67	53
Drawing related	15	6	9	54	67	47
Rework	15	5	10	54	56	53
Tools and equipment	9	4	5	32	44	26
Lack of Supervision	9	4	5	32	44	26
Overcrowded work area	7	5	2	25	56	11
Motivation	6	3	3	21	33	16
Personal problems	5	2	3	18	22	16
Labor related	4	2	2	14	22	11
Site related	4	2	2	14	22	11

Table 6: Ranking of Factors Influencing Productivity

Total People Surveyed=28 (ML-9; JL-19)	Points (pt.) Total Rank Order (1^{st} : 3pt / 2^{nd} : 2pt / 3^{rd} :1pt)			Relative index (RI) Number of Points/ (3*total people surveyed)		
Influence	**Total**	**Mid-level**	**Junior level**	**Total RI**	**Middle level RI**	**Junior level RI**
Materials	39	10	29	0.46	0.12	0.35
Rework	21	8	13	0.25	0.10	0.15
Tools and equipment	24	8	16	0.29	0.10	0.19
Design and engineering	19	6	13	0.23	0.07	0.15
Lack of Supervision	8	3	5	0.10	0.04	0.06
Drawing related	5	3	2	0.06	0.04	0.02
Overcrowded work area	9	4	5	0.11	0.05	0.06
Motivation	6	2	4	0.07	0.02	0.05
Personal problems	1	1	-	0.01	0.01	0.00
Labor related	3	1	2	0.04	0.01	0.02
Site related	2	1	1	0.02	0.01	0.01

FACTORS INFLUENCING CONSTRUCTION PRODUCTIVITY

The abovecalculated productivity factors show that the construction is mostly affected due to factors such as material, rework, insufficient tools and equipment and motivational practices etc. in spite of this additional information perceived that the promotion, incentives and bonus also plays key role in improving productivity. Such factors are explained in detail as follows. These factors are collected and discussed with the experienced employees that cause loss in productivity.

Materials

The survey results that the problem related to material such as:

- On time delivery of material from the suppliers and distributers.

- Lack of the material availability at the time of construction in the market.
- Lack of needful area for the storage of material; issue of material from the storage takes time such as filling requisition slip and the approving form engineer (paperwork).
- After receiving material from the storage the transportation of the material takes long time to the site.
- Worker also indicated that because of insufficient equipment to move material from storage to the site and then to start work such problems related to material influence the productivity of construction.

Rework

Employees experience indicated that primary cause of rework is as follows:

- The changes in drawing and specification which altered during or after the construction is the reason for the rework.
- Lack of project definition and the design error are also attributed to the rework.
- Lack of supervision and inspection at the time of ongoing construction activity causes rework.
- 25% cause of rework is due to misunderstanding and field error. Also lack of quality work of the construction also causes rework.

Tools and Equipment

The main reason stated that the number of insufficient tools and equipment to any site influence productivity in construction; The important tools which is required at the time of construction is not available on site; also the available tool and equipment broken are useless; The personal also indicated that the tool room was far from the site and was some time functional or non-functional; lack of knowledge of operating tools and equipment also influence productivity. Problematic tools used on site need careful use such as electric tool, electric, diesel and petrol pump, electric generators, electric hammer, pike, shovel, radios and electric extension etc. some of the instrument were consumables which finishes and have to be needed at the time of work. The unavailability of the heavy equipment at the time of work on the site influence productivity. It also depends on the type of organisation small or medium size organisation, it also depends on the type of equipment such as automatic or manual type used for increasing productivity.

Design and Engineering

The one of the important factors which influences construction productivity to greater extinct is construction design and engineering. Construction design and engineering for any project affect in terms of time, cost and quality. Useof precast material or modular construction instead of regular construction increase productivity.Changes in the design influence productivity also work force indicates that poor design and specification affects construction productivity, and engineer unfamiliar to the future field condition and unable to take decision. Use of new construction material also increases construction productivity for example using spray paint machine instead of using paint brush by workers.

Lack of Supervision

Previous study indicates that the lack of supervision affect the productivity in construction at the time of on-going construction work and also supervision after the time of construction. Also the present study shows that factor such as lack of supervision affect the productivity in construction. The engineer and supervisors inspect the on-going construction work so that the on-going construction work is done as in required manner. Delay in proper instruction given by engineer and

supervisors to the workers also influence productivity. Sometimes the high level of supervision is required for the particular work. A person with sound experience in the field of supervision will be required.

Motivation

Lack of motivation practices in the organization indicate and affects the construction productivity. Time to time motivational practices increase the employees and worker attitude towards the work. Human resource department of any organisation must take part in motivational practices for the construction employees and workers. Timely and effective promotion new responsibilities will also help in improving construction productivity. The motivational practices increases loyalty towards the work and reduce work fatigue. The workers of the organisation are mostly not having personal time to spend because of long work week system means Monday to Saturday (M-S). Organisation can opt for the different working shift (morning and night shift). Following table 7 shows the comparative study of productivity factors in India and other countries.

Table 7: Comparison of Productivity Factors that of in USA (Garner et al 1979), Chilean (Rodrigo A Rivas 2008) and Pune KPDL

USA Research (Garner et al 1979)		Chilean Case Study (Rodrigo A Rivas 2008)		Pune (India) KPDL Case Study (2013)	
Ranking	Productivity factors	Ranking	Productivity factors	Ranking	Productivity factors
1	Material	1	Material	1	Material
2	Tools	2	Tools	2	Rework
2	Waiting for quality control	3	Equipment and trucks	2	Tool and Equipment
3	Rework	3	Rework	3	Design and Engineering
4	Quality of supervision	4	Absenteeism	4	Lack of Supervision

CONCLUSIONS

In the above case study the main productivity influencing factors are found out by circulating questionnaire to various site of KPDL.Before that a detailed study of previous research has been performed for finding out the construction productivity factors. The questionnaire of these factors are prepared and circulated to various ongoing construction projects in Pune (KPDL, Goel-Ganga group, Sun properties, Atharvabuilders pvt.ltd). Following are some of the conclusions can be drawn.

- Some of the productivity factors such as design and engineering, rework, tools and equipment remain unchanged in the last 30 years in various countries.
- The role of the construction management is very important in the construction industry for improving the construction productivity. Every construction managers must take efforts for improving the construction productivity.
- As compared to previous studies the main productivity factors found out and ranked in the present case study are material, rework, tool and equipment, design and engineering, lack of supervision.
- With the help of the above case study for improving productivity of the constructionthe company management is now able to take decision in advance so that the construction productivity can be improved.

- And after finding this construction productivity factors the site managers are able to take appropriate and effective decisions for increasing construction productivity.

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